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## Farming dynamics

## **IRRIGATION TECHNIQUES**

IMPROVING SPATE IRRIGATION: THE EXPERIENCE OF FARMERS' COMMUNITIES IN WESTERN LOWLANDS OF ERITREA

## Overview

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## Introduction

Very ancient and still not very well known, spate irrigation constitutes the main source of subsistence for many farmers' families in arid and semi-arid areas of Asia, Africa and Latin America.

Spate irrigation also shows an important development potential. It can improve existing systems and it can be also be used in new areas.

The objective of this issue of Farming Dynamics is to explain a bit better this technique to a large public starting from the experiences of Farmers' Communities in Western Lowlands of Eritrea, and particularly the beneficiaries of a project that was implemented by the Eritrean Ministry of Agriculture in 2001 with the technical and financial support of SOS Faim and the Fonds Belge de Survie<sup>(1)</sup>.

Le Fonds belge de survie is a budgetary initiative by the Federal Parliament to palliate the consequences of the great famine in the 80's. The 5 year budgetary envelope is managed by the General Directorate of Development Cooperation. (http://www.dgcd.be/fr/acteurs/fond\_survie/index.html )

### **Spate Irrigation**

This section about spate irrigation is largely based on the manual «Improving Community Spate Irrigation »by P. Lawrence and F. van Steenbergen (2005)<sup>(2)</sup>, promoters of an international network of actors involved in the implementation and support of spate irrigation projects. We would like to thank them for their collaboration.

(www.spate-irrigation.org)

Many arid and semi-arid tropical regions have an important network of ephemeral rivers (oueds) that even during most of the dry season can carry big amounts of water in the few hours or days after the rare rains that often come in the form of violent storms. This is the particular case of certain desert lowlands bordering mountainous areas, generally more irrigated. Spate irrigation consists of diverting all or one part of the flood water and building dams in the river bed in order to carry the water through a channel towards plots surrounded by slopes. The irrigation causes an authentic flood in the plots, temporary reaching a water level of 0.5 m. or even more. Besides, the water transports big amounts of alluvia after each irrigation, contributing in this way to the fertilisation of the land. Generally, the crops are established just after the irrigation, and the residual humidity is enough to allow the crop to finish its cycle. These are mostly subsistence crops, normally sorghum. In some cases, however, it is possible to grow cotton in this way or even market gardening crops. This type of irrigation requires a fertile land, capable of stocking big amounts of water. In many cases the land is made fertile by the alluvia carried by the flooded water. For this reason, people say that these irrigation systems "produce" their own land.

Spate irrigation systems are different from most of the other irrigation systems that are based on a permanent source of water (reservoir, river, underground water). The highly unforeseeable number, sequence and volume of flooded waters need to be assessed. Furthermore, very powerful water streams have to be managed: in traditional systems, structures must be repaired or built from scratch after each strong flood, whereas the strong sedimentation in the plots and the regular diversions of the river course require readjustments rather frequently. Finally, the difficulty to share the irrigated water in an equal way between the plots can generate conflicts. The farmers' communities located upstream are generally more favoured, especially in the case of a weak flood. Managing spate irrigation projects is therefore a very delicate business and requires good cooperation among all farmers' communities that use them. However, in certain regions, farmers' know-how has been developed throughout the centuries, allowing the transformation of initially rudimentary systems into areas going from a few ha to more than 30.000 ha, with excellent and efficient results in both water usage and equality among users.

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In certain areas of Yemen, Iran and Pakistan, a group of archaeologists have found remains of structures that

Financed by the Department for International Development (DFID, British Cooperation), the document can be downloaded for free at these sites: www.hrwallingford.co.uk/publications/overseas.html and http://www.spate-irrigation.org/guide/guidehome.htm.

show that spate irrigation was already practised about 5.000 years ago. Since spate irrigation requires intensive hand labour, is not well paid and contains certain risks, it tends to disappear as soon as farmers have access to better economic opportunities, as is the case for Saudi Arabia.

## **Formal and Informal Initiatives**

The intervention of public authorities and development agencies generally try to reduce the labour needs for the implementation and maintenance of structures either building permanent structures in masonry or in gabions, or making available civil engineering machines to establish and maintain the bank slopes in the plot, or a combination of both strategies. The construction of reservoirs upstream to store the water and avoid problems related to calendar uncertainties and the volume of flood water is normally not a feasible option due to the heavy content of sediments that would fill the reservoir in a few years.

From the 60's, big investments have been approved in civil engineering for vast areas in the framework of public development programs in Yemen and to a lesser extent, in Pakistan, Eritrea and Tunisia. However, even today, most spate irrigation projects are managed by farmers from the informal economy. FAO official statistics (2005) show that about 2.3 million ha are irrigated in this way in 13 countries of the Near East, Middle East and Africa:

## Table-1: Extension of spate irrigation in certain countries

Country	Year	Spate irrigated surface (ha)
Algeria	1992	110.000
Eritrea	1993	15.630
Kazakhstan	1993	1.104.600
Mongolia	1993	27.000
Morocco	1989	165.000
Pakistan	1990	1.402.448
Somalia	1984	150.000
Sudan	1995	46.200
Tunisia	1991	30.000
Yemen	1994	98.320

Source: FAO Aquastat, 2005

However, FAO statistics are based on national official data that often ignore the activities of farmers' informal economy. Besides, other sources mention the practice of spate irrigation in other countries such as Chile, Bolivia, Mauritania, Senegal, Ethiopia, Kenya, Egypt, Iran and Afghanistan. In fact, P. Lawrence and F. van Steenberg (2005) consider that the real extension of spate irrigation at least doubles the surface shown by the FAO official statistics.

Being associated with low value subsistence crops and high risks, spate irrigation has awoken a rather limited interest of public authorities and development agencies. Furthermore, for several reasons, most big projects have not reached the initially expected results. However, according to the authors already mentioned, spate irrigation shows an important development potential in arid countries with low income, both through the improvement of the existent traditional systems and through the development of new





areas still unexploited. In fact, this is the case in countries such as Ethiopia and Eritrea, where the areas irrigated in this manner increase every year. Particularly, the improvement projects of farmers' systems with a more modest scope seem to obtain more encouraging results.

In their manual, P. Lawrence and F. van Steenberg formulate a series of recommendations, of which we have selected the most important ones:

- Regardless of the size of diversions, the user farmers' must be the ones who direct the design, planning and execution of the improvement works or structures to be repaired. The technicians role is limited to explaining the available options and to help the farmers choosing the most appropriate improvements for their area (most failures in improvement projects of big areas come from a lack of participation of user farmers);
- In many cases, preference should be given to easy and economical techniques to improve pre-existent structures, rather than building new structures from scratch, and abandon the existing traditional structures;
- Spate irrigation tends to reload the aquifer in the land, therefore, if there are sources of underground water that are not very deep, spate irrigation should be combined with the exploitation of underground water through pumps, enabling in this way market gardening crops with a high added value out of season;
- In order to maximise the effects, rural engineering interventions on

irrigated areas should be combined with interventions on the other elements of crops productivity: improving harvesting techniques, introducing better performing varieties and new species, including non subsistence species (yield crops, fodder crops); reducing the after harvest loses, organising the seeds supply and commercialisation of products, etc.

 Confronted to the hazards of spate irrigation, farmers normally develop a strategy to diversify their sources of income by conducting parallel activities, particularly livestock farming. The interventions for the development or improvement of spate-irrigated areas with a view to reduce poverty should be combined with actions that favour other income generating activities.

## Origins of the Eritrean Experience

Eritrea is a country from the horn of Africa bordered by the Red Sea, Djibouti, Ethiopia and Sudan. Its surface of 123.000 km<sup>2</sup> is composed of a central high plateau (1600-2600 m) surrounded by lowlands (0-800m) West, North and Eastwards. The semi-arid climate varies according to altitude and latitude. The subsistence agriculture is practised at the centre and south of the high plateau, as well as in the South-Western lowlands. Outside, the too arid climate is only compatible with extensive livestock farming or irrigated crops when water is available. There are about 3.5 million inhabitants, 70 to 80% of which live in rural areas. It occupies the 161st place in the country classification that appears in the UNDP report (2005)



about human development and its GDP is 170-220 USD per inhabitant. In fact, Eritrea is one of the poorest countries in the planet. Agriculture depends a lot on a highly uncertain rainfall index and is confronted to an underlying conflict with Ethiopia. The agricultural production fluctuates every year going from 100.000 to 400.000 tons, which does not even cover half of the country alimentary needs, estimated to be more then 800.000 tons per year. The spate-irrigated crops cover about 14.000 ha, about half the total of the irrigated surface (28.000 ha) but only 3% of the total harvested surface (472.000 ha). There is, however, an important development potential, between 60.000 and 90.000 ha. Developing spate irrigation is one of the key elements of the Eritrean governmental strategy to improve food security in the country.

Spate irrigation was introduced in the Eritrean Eastern lowlands some hundred years ago by Yemen immigrants. Being a narrow arid stripe trapped between the Red Sea and the central high plateau, the Eastern lowlands is the place where several ephemeral rivers from the high plateau come to die. During the rainy season big amounts of flood water accumulate there, they hurtle down the abrupt Eastern escarpment before they flow in the lowlands. According to Tesfai and Mehari (2003) a dozen sites of significant size are currently exploited. Only one of these sites (Sheeb) was the object of important investments in civil engineering. Apart from that, flood waters are always diverted through temporary structures established with branches of Acacia nilotica, which has a dense and rigid thorny structure that catches several floating sediments and debris. Flood waters are concentrated

in relatively limited surfaces. After being irrigated, the plots are ploughed. At the end of the flood season, plots are covered by a layer of sand in order to limit evaporation. These intensive methods offer particularly high yields: up to 35 q / ha at the first cutting and still about half at the new growth<sup>(3)</sup>. Irrigated areas vary from hundreds to thousand ha depending on the sites.

In the Western lowlands, there is no tradition of spate irrigation comparable to the situation in the Eastern lowlands. However, in a small scale, agro-shepherds exploit the flood water of certain streams that they divert towards cultivated plots using branches, stones and earth. In this traditional small-scale practice (a few ha) irrigation supplements the generally insufficient input of rain and farmers continue to divert flood water even when the crops are already established. This practice can only be applied in crops that receive temporary floods, such as millet and sorghum.

Inspired in this traditional practice, several spate irrigation projects have been implemented since the 80's after the initiative of the Ministry of Agriculture<sup>(4)</sup>, in most cases with the technical and financial support of development agencies. Contrary to the strategy adopted in the Eastern lowlands, the objective here is to transfer the diverted flood waters into rather large surfaces where they act as a supplement to the rain input and the irri-

<sup>4)</sup> Before the country became independent in 1991, spate irrigation projects were directed by the Agricultural Department of the Eritrean Popular Front for Liberation, in the areas that were controlled and administered at the time by the Front.



<sup>3)</sup> According to Mehari and Tesfai (2003): http://www. spate-irrigation.org/librar/spateiniretrea.htm

gation continues during the crop. The extension of the irrigated areas generally varies between 50 and 300 ha.

However, a study conducted in 2001 by W.I. Robinson<sup>(5)</sup> concluded that most of these projects stopped working totally or only worked at a lower level than expected for the following reasons: lack of involvement of user farmers in the design of diversion schemes, excessive complexity of diversion schemes in relation to the farmers' capacities; lack of farmers' organisation for the management and maintenance and lack of follow-up by the Ministry of Agriculture.

### **New Initiatives**

From the current year, the Regional Bureau of the Ministry of Agriculture of Gash-Barka<sup>(6)</sup> has strengthened its team of civil engineering technicians and refocused its strategy highlighting farmers' participation in the initial concept and maintenance of diversion schemes. Furthermore, the encouraging results obtained this year have awoken an increasing interest in farmers and development agencies. In this way, from 2001 to 2005 twenty schemes with a capacity of 50 to 400 ha have been created or rehabilitated.

In the framework of a co-financing programme with the Fonds Belge de Survie from 2001 to 2006, SOS Faim has given a significant contribution to this evolution by financing the provision of equipment, specialised technical assistance and the creation or rehabilitation of 7 diversion schemes. The following information is extracted from specific reports of these 7 diversion schemes<sup>(7)</sup> but can be applied in a general way to all diversion schemes created or rehabilitated in the last years by the Ministry of Agriculture in the Gash-Barka Region.

The 7 diversion schemes are situated in the Northern half of the Gash-Barka Region were the rainfall index is less than 400 mm per year, and therefore insufficient to guarantee the success of rainfed crops.

The selection of sites has been done in several stages: (1) selection of the most vulnerable villages with the Administration and the Ministry of Agriculture; (2) identification of potential sites for each village by the chiefs of these villages; (3) final selection of sites based on criteria of technical feasibility and the motivation of farmers with rights on the concerned plots or likely to cultivate them.

Once the sites have been identified the beneficiaries are selected giving priority (if necessary) to farmers who own traditional rights over the concerned plots with a maximum of 2 ha per family. Such rights normally exist on previously exploited sites in rainfed crops or "traditional" spate irrigated crops. If these rights concern areas of more than 2 ha, the surplus is reassigned to other local farmers who do not own irrigable land or to immigrants (mostly to Eritrean refugees in Sudan in the 70's and 80's, repatriated from 1991). The allocation has been established by the local Administration taking into account the farmers' socio-



<sup>(5)</sup> Robinson, W.I., Preliminary Study and Formulation of a Small-Scale River Diversion Development Programme in the Western Lowlands of Eritrea, University of Bangor, 2001 (available at SOS Faim).

Administratively speaking, Eritrea is divided in 6 Regions. Most of the Western Lowlands is situated in the Gash-Barka Region.

Particularly the report of an evaluation mission carried out in February-March 2006 by Tesfai Haile and Vincent Lefebvre (available at SOS Faim).

economical situation and their capacity to value the plots that are given to them. The same process is applied when the diversion scheme is made in "communal" land (pasturage areas traditionally accessible to every body or to all the members or certain clans or ethnical groups).

On each of the 7 sites, several workshops were held with the beneficiary farmers and local Administration officials and the Ministry of Agriculture in order to determine the collaboration terms and to agree on the different aspects of the diversion concept, taking into account both the farmers' knowledge and the conclusions of technical studies carried out at the same time. Once the diversion scheme has been constructed, the Ministry of Agriculture officials provide the training of farmers and a regular follow-up. Whereas the initial cost of construction of diversion schemes is totally covered by the projects, the maintenance is normally run by farmers -with the exception of important damages, in which case support can be negotiated at the Ministry of Agriculture.

### A diversified framework

The technical support of the Ministry of Agriculture is not only limited to aspects of rural engineering but it is also extended to crops management. In fact, in a context where rainfed crops are highly hazardous, farmers traditionally adopt an extensive strategy. Taking into account the high chances of failure, it would not be reasonable to invest a lot of time in cereal crops. On the contrary, it is preferable to focus on livestock farming, less vulnerable to rainfall hazards. The farmers strategy can also be considered "defensive", since it gives priority to varieties and practices aiming to obtain a minimum production of fodder and possibly grains, rather than aiming at high yields in grains, which depend on rainfall conditions that only take place every 5 or 10 years. However, in a new context in which the diversion schemes bring an input of water that although it is not guaranteed it is at least much more probable, this traditional farmers' strategy is no longer justified. In order to take the most advantage of the important investments in the hydro-agricultural infrastructures, the Ministry of Agriculture should offer technical support to the farmers so that they can select and successfully apply the techniques and agronomical innovations that will allow them to maximise the yield of their crops.

Finally, the technical support must also be extended to the organisation of the beneficiary farmers. In fact, although agriculture is traditionally a family activity, the establishment of spate irrigation structures and certain aspects to improve crops practices require that certain functions be managed in a collective way (water management, maintenance and repairing of structures, renting of agricultural machinery, seeds supply, communication with the support service, etc). The establishment of collective farmers' structures is also a key element to make the beneficiaries responsible for the management of the diversion schemes.

The capacity (irrigable surface) of diversion schemes varies between 70 and 420 ha and 1375 ha for the 7 diversion schemes. Initially, in order to facilitate management for farmers, they chose un-gated diversions that divert each flood systematically. The



weir, however, is provided with a spillway in order to limit the water input in case of strong floods and to protect the diversion scheme from destruction. However, it was proved that floods brought important amounts of sand that progressively placed on the plots would limit to a few years the useful life of the sites. For this reason, in all diversion schemes built from 2003, a gates system has been installed at the entrance of the main channel leading to the plots. The closed or opened position of these gates determines whether the flood water is diverted towards the plots or whether the water follows its natural course in the river bed. Furthermore, the dam is equipped at the lower end with a sluice gate, located below the gates level of the main channel, and in the opened position, it eliminates the lower layer of the flood, which is the most loaded with sand. In this way, only the higher layer, loaded with only fine sediments will be admitted to the main channel. These equipments allow a better use of irrigation. The non-diverted flood waters remain available for potential users downstream and protect the crops from silting-up. However, they need a rigorous management by farmers, who must organise a guard on the site day and night during all the rainy season in order to control the opening and closure of gates in case of floods. On 2 of the 5 sites equipped with gates farmers make shifts to control the opening and closing of gates. For the other 3 sites farmers have assigned this task to guards, paid through contributions.



<sup>8) 350</sup> Nakfa / hour, versus 280 Nakfa / hour for the governmental services.

9) Norwegian People's Aid, www.npaid.org

## Modifications of farmers' traditions

From the first year, farmers have become aware of the opportunity offered by diversion schemes and they have all focused their attention on managing their plots. This means, in particular, that farmers visit regularly their plots, most of which are weeded on time.

Most farmers have abandoned the traditional practice of direct sowing (zero tillage) for the mechanical plough with tractor, offered by the regional government at a subsidised price. Mechanical ploughing delays the early invasion of weeds in the plots. Unfortunately, the demand of such services is higher than supply, therefore, it is common practice to plough the plots (and sow them) rather late. This is a difficult problem since ploughing can only be done on humid soil, a few hours or days after the rare rains (or irrigations). There are only a limited number of days to do this job. Ploughing by camel traction is also practised in the region but it is not a feasible alternative because it demands very intensive labour (2 people must accompany the camel, one to guide it and the other to hold the cart) and this method does not allow ploughing big surfaces in little time. Agricultural undertakers also offer tractor-ploughing services at slightly higher commercial rates<sup>(8)</sup>. All theses services do not seem to have interested farmers until now. As an answer to this problem, a Norwegian NGO<sup>(9)</sup>, active in the Gash-Barka region until 2005, had led an original experience providing tractors to two farmers' communities that use spate irrigation techniques. Unfortunately we do not have detailed information about this experience, generally considered in the country as a decisive experience.

With the exception of the still timid adoption of improved varieties of sorghum, farmers continue to use their ancestral habits, although trying to be slightly more skilful: sowing millet or sorghum, leading to heterogeneous densities of population in the plots; hand weeding (without tools) related to the sowing mode (weeding with hoe can only be done in crops sowed in lines); keeping the collected grains in bags stockpiled on the ground, thus favouring important risks of loses after the harvest, etc. Tesfai Haile and V. Lefebvre (2006) suggest that this conservative attitude can be linked to a strategy to reduce risks (fodder byproducts, less vulnerable to water deficit) rather than at maximising the grain yield. We believe, however, that techniques such as seed priming, exploiting new growths after ratooning, introducing leguminous plants, fodder crops or market gardening crops intercropped with the main cereal crop, catch crops, etc, are worth trying by voluntary farmers with the support of the Ministry of Agriculture.

On each of the 7 sites, the beneficiary farmers have created an association. Since they lack an appropriate legal framework, these associations are informal, which, for example, does not allow them to open a bank account (certain associations have nonetheless carried out this activity under the pretence of the Ministry of Agriculture). Each association has created a Committee composed of 5 to 7 members whose task is to organise the guards to control the opening and closing of gates (on the 5 sites concerned), the maintenance of non permanent structures, contacts with

the Administration and the Ministry of Agriculture, etc.

However, the organisational structure of these associations is still in its embryonic stages. Only the organisation of guarding shifts in the flood season and minor maintenance activities are really taken up by farmers. For more important repairs farmers take recourse systematically to the Ministry of Agriculture, contradicting the collaboration spirit. Only one association has started thinking about organising other services and the necessary increase of contributions to this end.

Despite the problems already mentioned, diversion schemes have already allowed farmers to obtain important production increases. These are calculated from irrigated surfaces and yields are measured by sampling on irrigated lands and adjacent rainfed plots. In 2005, an "average" year from the rain index perspective, the yield on irrigated plots, grain and stalks increased respectively to 7.9 g/ha and 1.063 bunches<sup>(10)</sup>/ha, which can be compared with increases in the yields measured in the adjacent rainfed plots (2.6 g/ha and 410 bunches/ha.) On the basis of effectively irrigated surface, the 7 sites have allowed 851 farmers' families to obtain a supplementary production of 692.6 tons of grains and 857.260 bunches of millet and sorghum stalks. Considering the price of these products on local markets during the harvest and the supplementary costs related to the sites (including the amortisation of the initial investment<sup>(11)</sup>), the net advantage

<sup>11)</sup> Over 15 years for gated systems and over 5 years for un-gated systems.



<sup>10)</sup> Millet and sorghum stalks are sold in the market in bunches of ± 4 kg.

for the beneficiary families is on average 4.909 Nakfa<sup>(12)</sup> (268 EUR) per family<sup>(13)</sup>.

### Conclusion

Practised for thousands of years in the arid regions crossed by ephemeral rivers, spate irrigation shows still today an important development potential in low-income countries. External interventions such as the construction of permanent structures with modern materials or providing civil engineering machinery can help reducing the labour need for the construction and maintenance of infrastructures and to improve the productivity of user farmers. The management of spate irrigation systems still remains a delicate business and for it to be successful a solid farmers' organisation is needed.

The experience carried out by the Eritrean Ministry of Agriculture in the Gash-Barka region with the support of international development agencies shows that the creation of spate-irrigated areas significantly increases the yield of local traditional subsistence crops and, therefore, farmers' income. On diversion schemes of limited size (70-420 ha), it has been possible to encourage the creation of farmers' organisations capable of taking responsibility for managing the diversion schemes in the spate season and doing minor maintenance works to the infrastructure. However, they still need substantial accompanying work to make the farmers' associations less dependent on public services, to do more important repairing works and to make farmers benefit permanently from these diversion schemes.



<sup>12)</sup> Eritrean national currency. Official exchange rate on 28.02.2006: 1 EUR = 18.33 Nakfa.

<sup>13) @</sup>For a 5 member family beneficiary of the average national income, about 200 USD per year, this represents a 30% income increase. In fact, the advantage of the beneficiaries of this project is higher, since the last one takes into account the initial investment.

#### All issues of Farming Dynamics are available on request (info.be@sosfaim.org).

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## Furthermore, SOS Faim also publishes a newsletter on microfinance: "Zoom Microfinance" which is also available on the internet site www.sosfaim.org .

#### Recent issues of "Zoom microfinance":

- The link between a micro finance institution and the modern banking sector: the cases of MC2, the NGO ADAF and Afriland First Bank in Cameroon.
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## Farming dynamics



#### SOS Faim and farmers organisations

Since 1964, SOS Faim Belgium and, since 1993, SOS Faim Luxembourg support farmers and agrarian producers organisations in some 15 countries in Africa and Latin America.

Their actions are built around three working themes: the support of institutional and organisation development, the support o economic activities and the defence of the interests of the Southern producers in Belgium, Luxembourg and Europe. In this framework, SOS Faim Belgium and Luxembourg have created "Farming Dynamics", a quarterly bulletin issued in French, Spanish and English.

The objectives of Farming Dynamics are the following:

■ To make known these farmers' and producers' organizations on the largest scale possible: their actions, their experiences. Their problems, their solutions. Their positions and proposals on matters of their concern.

■ Organize debates, exchange of experiences and ideas on subjects like their own development, or the future of agriculture, of the rural world;

Inform politicians who have an influence on these organizations activities in the South.

If you would like to react about the themes dealt with in this issue of Farming Dynamics, or if you would like to give us your opinion or contribute some information please contact us at: info@sosfaim.org

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